

Soil Organic Carbon Sequestration from Animal Manure Applied to and Dropped onto Pastures



Authors

Alan J. Franzluebbers, Ecologist
John A. Stuedemann, Animal Scientist (retired)

1420 Experiment Station Road
Watkinsville GA 30677
Tel: 706-769-5631
Email: alan.franzluebbers@ars.usda.gov

Technical Support

Steve Knapp, Eric Elsner, Dwight Seman,
Devin Berry, Kim Lyness, Josh Cown
Amanda Limbaugh, Robert Martin, C.J. O'Mara

Financial Support

USDA-ARS Soils CRIS (6612-11120-003-00D)
"Soil Organic Matter and Nutrient Cycling
to Sustain Agriculture in the Southeastern USA"

USDA-ARS Global Change CRIS
(5402-11120-NEW-00L)
"GRACEnet (Greenhouse Gas Reduction
through Agricultural Carbon Enhancement network):
An Assessment of Soil Carbon Sequestration and
Greenhouse Gas Mitigation by
Agricultural Management"

Issues

Animal manure can be a valuable nutrient source
for pastures, but whether and how it contributes
to soil organic C sequestration are unclear.

Long-term estimates of soil organic C
sequestration in pastures are limited, but are
needed to improve understanding of management
influences on greenhouse gas emissions and
soil quality.

How pastures are supplied with animal manure
could affect soil organic C sequestration.



Methods

Environmental characteristics

- Southern Piedmont Major Land Resource Area
- 16.5 °C - mean annual temperature
- 1250 mm - mean annual precipitation
- 1560 mm - mean annual pan evaporation
- Cecil-Madison-Pacole dominated soils (fine, kaolinitic, thermic Typic Kanhapludults)
- Severely eroded site following tilled cropping

Management variables

Fertilization regime

Phase I (1994-1998) - all supplying 200 kg N · ha⁻¹ · yr⁻¹
to bermudagrass (*Cynodon dactylon*; summer grazing)
(a) inorganic only
(b) crimson clover (*Trifolium incarnatum*) + inorganic
(c) broiler litter

Phase II (1999-2005) - all supplying 270 kg N · ha⁻¹ · yr⁻¹
to tall fescue (*Lolium arundinaceum*)/bermudagrass
mixture (year-round grazing)
(a) inorganic only
(b) low broiler litter (1x) + inorganic
(c) high broiler litter (3x)

Forage harvest strategy

- (a) unharvested (CRP simulation)
- (b) low grazing pressure (4 Mg ha⁻¹ available forage)
- (c) high grazing pressure (2 Mg ha⁻¹ available forage)
- (d) hayed monthly

■ 3 replications in a split-plot factorial arrangement of
fertilization (main plot) and harvest strategy (split plot)

Sampling

- Soil and surface residue sampled at 5, 8, and 12
years of management
(a) Surface residue mass and C content
(b) Soil C concentration determined at 0-3, 3-6, 6-12,
and 12-20 cm and summed as 0-20 cm
(c) Bulk density measured to determine total C content
- Soil sampled horizontally in 3 zones:
(a) 5 m from shade/water (Shade)
(b) 30 m from shade/water (Mid)
(c) 80 m from shade/water (Far)

Results

Broiler litter applied to bermudagrass pasture



Cattle manure dropped onto bermudagrass pasture



Years of Management	(External input)			(Internal input - recycled from on-site production of forage)			
	Inorganic	Low Broiler Litter	High Broiler Litter	Unharvested	Low Grazing Pressure	High Grazing Pressure	Hayed
0							
				Manure C Inputs (Mg C / ha / yr) – 1 to 5 Years			
	0	0	1.8	0	1.4	2.0	0
				Surface Residue C (Mg C / ha) – End of 5 Years			
	2.2	> 1.6	1.4	2.5	> 2.1	1.5	> 0.9
5				Soil Organic C (Mg C / ha / 20-cm depth) – End of 5 Years			
	42.1	43.0	43.4	40.7	< 44.6	43.1	> 38.9
				Manure C Inputs (Mg C / ha / yr) – 6 to 12 Years			
	0	0.9	2.7	0	1.4	2.0	0
				Soil Organic C (Mg C / ha / 20-cm depth) – End of 8 Years			
8	34.7	35.2	35.5	33.3	< 37.1	35.7	> 29.5
				Surface Residue C (Mg C / ha) – End of 12 Years			
	2.4	2.6	1.9	4.0	> 2.5	1.7	1.9
				Soil Organic C (Mg C / ha / 20-cm depth) – End of 12 Years			
12	38.7	39.4	40.2	37.6	< 42.1	39.6	> 32.5

Interpretations

- Soil organic C in the surface 20 cm at the end of 12 years of pasture management averaged 39.4 Mg C / ha compared with an estimated initial value of 29.9 Mg C / ha, suggesting a mean sequestration rate of 0.79 Mg C / ha / yr.
- Manure C input with broiler litter ranged from 0.9 to 2.7 Mg C / ha / yr resulting in mean yearly input values of 0.5 to 2.4 Mg C / ha / yr (averaged across 12 yr) in low and high broiler litter application rate treatments.
- No significant difference in soil organic C could be detected between pastures managed with and without broiler litter application, despite the large input of C with broiler litter. This lack of difference suggests rapid decomposition of broiler litter in this environment.
- Surface residue C was not positively affected by broiler litter application. Surface residue C was a function of how pasture was managed by harvesting intensity (i.e., haying and grazing pressure).
- Manure C input from cattle grazing directly on pasture increased soil organic C at 5, 8, and 12 years.
- Soil organic C was more positively influenced by cattle manure dropped onto pasture than from broiler litter applied to pasture as supplemental fertilizer.